Mapping wind resources - state of the art

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Mapping wind resources – state of the art

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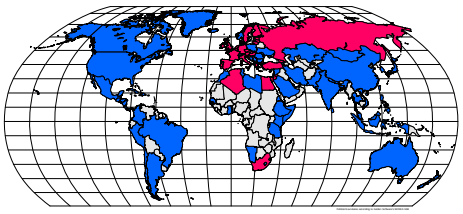
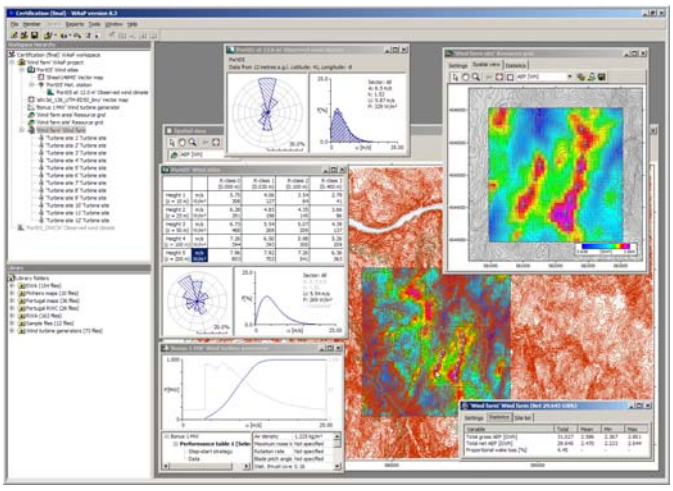
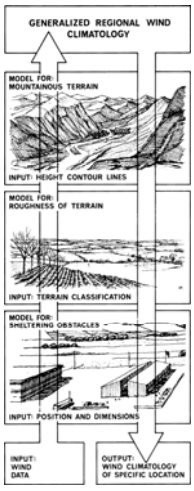


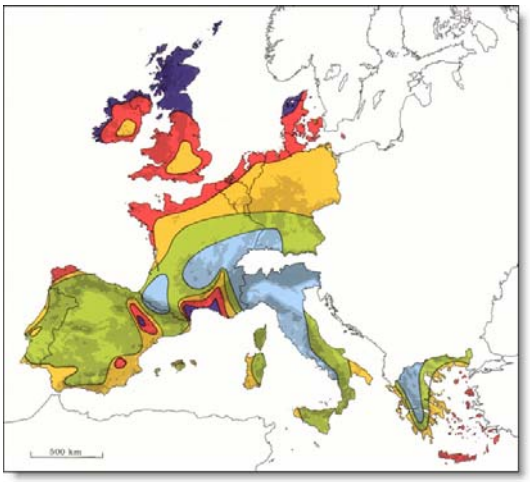
Risø DTU
National Laboratory for Sustainable Energy

Observational wind atlas





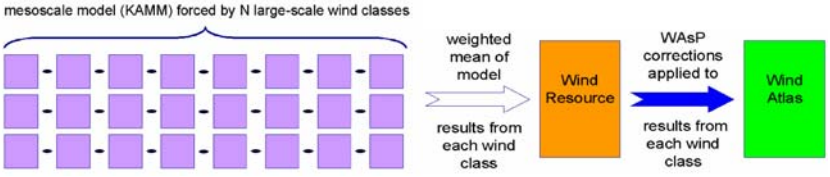
European Wind Atlas



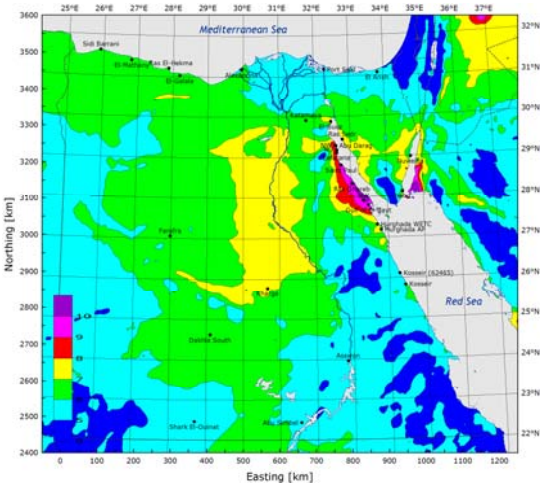
- 12 countries in Europe
  - EU project 1981-89
- 220 met. stations
  - Wind data for 10 years
  - wind atlas analyses
- 656–page book
  - EU wind potential
  - handbook of siting
  - database of wind
- CD-ROM containing
  - observed wind data
  - modelled wind data
- Applications
  - only overall planning

Numerical wind atlas – mesoscale

- Inputs
  - NCEP/NCAR reanalysis data-set
  - terrain topography – elevation and roughness – satellite and SRTM data
- Outputs
  - generalised regional wind climate for large domains
- Applications
  - planning and project preparation
  - assessment of mesoscale effects at wind farm projects

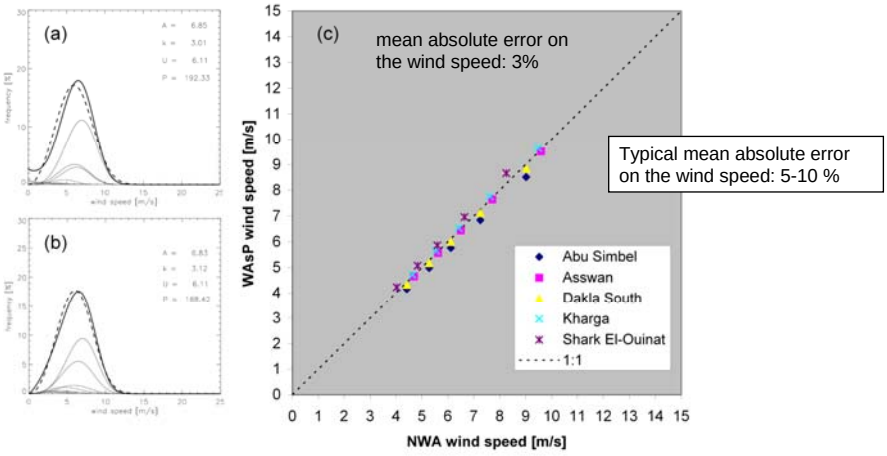


Numerical Wind Atlas for Egypt



- Numerical wind atlas
  - NCEP/NCAR data
  - mesoscale modelling
  - SRTM30 elevations
  - GLCC land use
- Observational wind atlas
  - 30 met. stations
  - microscale modelling
  - SRTM3 elevations
  - Land use from GE
- Comprehensive outputs
  - Wind Atlas for Egypt
  - OWC/RWC databases
  - > 50,000 *.lib files!
  - Verified and reliable
  - Application ready!

Verification – example



State-of-the-art wind atlas methodology

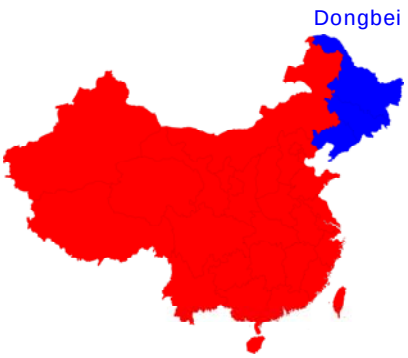
Mesoscale	**Pre-processing** Wind classes Terrain elevation Terrain roughness Input specifications Model setup	**Modelling** KAMM WRF MC2 MM5 etc.	**Post-processing** Predicted wind climate Regional wind climate Predicted wind resource for selected terrain site coordinates	**Numerical WA** Mesoscale maps Database WAsP *.LIB files Uncertainties Parameters
Measurements	**Met. stations** Siting Design Construction Installation Operation	**Wind data** Data collection Quality control Wind database Wind statistics Observed wind climate	**Verification** Meso - and microscale results vs. measured data Adjust model and model parameters to fit data Satellite imagery (offshore sites only)	**Applications** Best practices Courses and training Microscale flow model Wind farm wake model ⇒ **Wind farm AEP**
Microscale	**Pre-processing** Wind speed distributions Wind direction distribution Terrain elevation Terrain roughness Sheltering obstacles	**Modelling** WAsP MS-Micro CFD-models etc.	**Post-processing** Regional wind climate Predicted wind climate Predicted wind resource for selected terrain site coordinates	**Observational WA** Microscale maps Database WAsP *.LIB files Uncertainties Parameters

Mesoscale and microscale modelling in China

"Sino-Danish Wind Energy Development Programme" - Dongbei 2008-2009

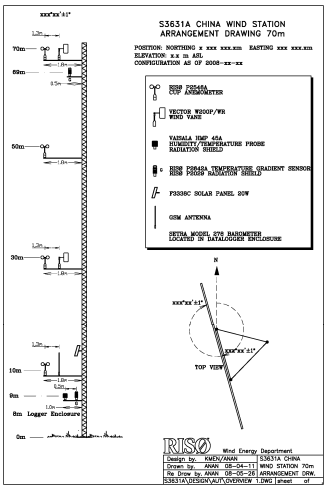
Strategy

- Twinning arrangement – initiate long-term, strategic cooperation between CMA and Risø DTU
- Development of numerical wind atlas methodologies
- Development of measurement practices
- Emphasis on application of results for wind energy planning and project preparation.
- Emphasis on verification and uncertainties
- Full-scale testing and verification in Dongbei: Liaoning, Jilin and Heilongjiang



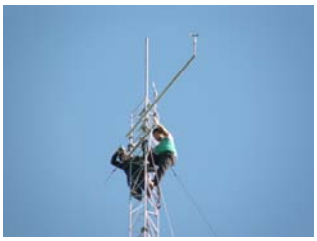
Measurements

- Lattice-type meteorological towers
  - 12 tall masts (70 & 100 m)
  - accurate installation of sensors
  - easy inspection and maintenance
- Sensors
  - high-quality, double instrumented
  - wind speeds at 3 or 4 levels ⇒ vertical wind profile
  - temperature difference sensors ⇒ atmospheric stability
- Data acquisition system
  - Daily GSM transfer to database
  - local backup in logger
  - high data recovery rates



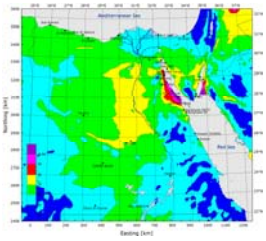
70-m mast installed in Dongbei

70-m mast installed in Dongbei

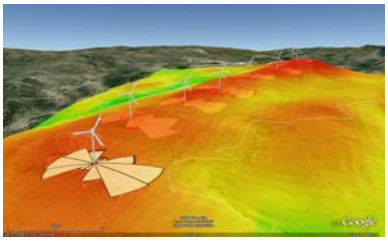


Modelling

- **Mesoscale modelling**
  - KAMM/WAsP numerical wind atlas
  - covers large areas
  - fast and cost-effective
  - regional wind climate @ grid points
  - provides inputs for microscale
  - comparisons of several models: KAMM, WRF, MM5 and MC2



- **Microscale modelling**
  - analysis of 12 met. towers
  - analysis of CMA met. stations
  - WAsP observational wind atlas
  - regional wind climate @ tower
  - parameter studies used for localisation of model setup
  - same model as for applications



By the end of 2009

- **12 measurement stations** in operation
  - nine 70-m + three 100-m masts
  - double instrumentations: Risø and CMA

- **Observational Wind Atlas**
  - measurements and microscale modelling
  - for regions close to the towers and met. stations

- **Numerical Wind Atlas**
  - reanalysis data and mesoscale modelling
  - covering all of Dongbei with a resolution of 5 km

- **Verification** of numerical wind atlas against towers and met. stations

- **Databases, tools and guidelines**

Ideas for the future

So, the mean wind climate is being done now, what's next…?

Here are some quick ideas:

- Wind conditions and site assessment (IEC 61400-1)
  - extreme winds
  - wind profiles and shear
  - terrain and flow angles
  - free-stream turbulence intensity
  - wind farm wake turbulence
- Extreme Wind Atlas
- More on stability effects
- Long-term wind climatologies at reference stations
- …

And, not to forget, application of improved methodologies to all of China!